2.3.3 Oxbow Reservoir (RM 285 to 272.5):

The Oxbow Reservoir segment (RM 285 to 272.5) includes Oxbow Reservoir from the outflow of Brownlee Dam to Oxbow Dam (Figure 2.3.24). This segment is much smaller than the Brownlee Reservoir segment (RM 335 to 285), and has an average retention time of only 1.4 days (Table 2.3.23). Oxbow Reservoir has a surface area of about 1,000 acres and approximately 26 miles of shoreline. Flow into Oxbow Reservoir is almost exclusively the outflow of Brownlee Reservoir. Wildhorse River, the only major tributary to this segment, flows directly into the reservoir near the Brownlee Dam and constitutes less than 1 percent of the total inflow. Total reservoir volume is 57,500 acre-feet. Flow and residence time within the reservoir are controlled by the releases from Brownlee Reservoir and the releases from Oxbow Dam. Oxbow Reservoir is not operated for flood control. Due to its relatively small size, highly controlled inflow and outflow, and short residence time, water management and water quality concerns in this segment are well correlated with the reservoir boundaries (IPCo, 1999a, 1999c).

Table 2.3.23 Physical characteristics of Oxbow Reservoir.

Date Closed	1961
Full Pool (feet msl)	1,805
Minimum Pool (feet msl)	1,795
Total Volume (acre-feet)	57,500
Surface Area (acres)	1,157
Mean Depth (feet)	50
Length (river miles)	12
Mean Width (feet)	795
Shoreline (miles)	26
Average Retention Time (days)	1.4

2.3.3.1 INTRODUCTION

For a discussion on the effect of impoundments within the SR-HC TMDL reach see Section 2.1.1.4

While most of the processes discussed in Section 2.1.1.4 can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Brownlee Reservoir, located in the farthest upstream position in the Hells Canyon Complex, acts as a sink for both sediment and nutrients within the Hells Canyon Complex and downstream river segments; deep-water releases also act to lower water temperatures in downstream segments. To a lesser degree, Oxbow Reservoir acts in this same capacity and reduces sediment and attached pollutants that might otherwise enter downstream segments. While these changes in transport can act to improve water quality, the agencies prefer to prevent the initial pollutant loading into a water system than to depend on instream treatment systems (ODEQ, 1999).

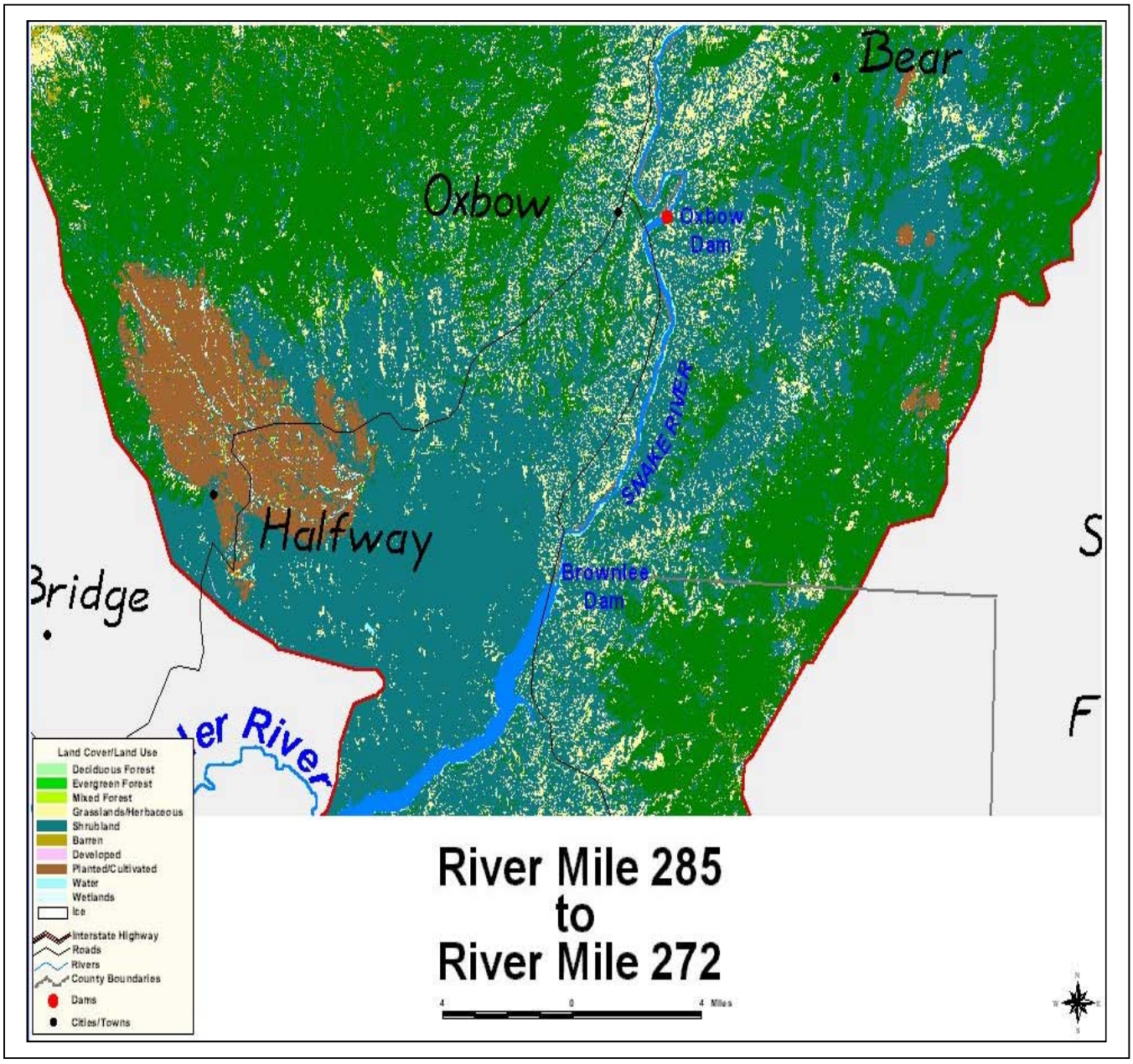

Figure 2.3.24 Oxbow Reservoir segment of the Snake River – Hells Canyon reach.

2.3.3.2 WATER QUALITY CONCERNS/STATUS

General Information

The waters in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach are listed as water quality limited for temperature, mercury, pesticides, sediment and nutrients (Table 2.3.24). A more detailed examination of the data available for this assessment has identified two of these pollutants (pesticides and mercury) for which the listings depend on data and interpolation from upstream sources. The rest of the pollutants appear, from the existing data (historical as well as current), to be limiting the attainment of the designated beneficial uses in this segment. Each of the pollutants and its potential impact on this segment of the SR-HC TMDL reach is described in more detail in the following sections.

Listed Pollutants and Designated Beneficial Uses

Table 2.3.24 summarizes the listed pollutants and designated beneficial uses for the Oxbow Reservoir segment (RM 285 to 272.5). A more detailed description of each of the designated beneficial uses is included in Section 2.2.2. A more detailed description of the listed pollutants and the assessment process is located in Section 3.0 through 3.7.

Table 2.3.24 Listing information for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Idaho Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 285 to 272.5 Oxbow Reservoir	Nutrients, sediment, pesticides	Cold water aquatic life primary contact recreation domestic water supply special resource water
Segment	**Oregon Listed Pollutants**	**Oregon Designated Beneficial Uses**
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	Public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower

* Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

The primary salmonid species in this segment are rainbow trout and mountain whitefish. The general spawning periods for these two species are March 01 to July 15 and November 01 to March 30, respectively. Resident fish include cool and warm water fish as bass, crappie, and catfish. The dominant community in the Oxbow Reservoir segment (RM 285 to 272.5) is the resident cool and warm water fish.

Summary and Analysis of Existing Water Quality Data

Mercury.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed as water quality limited due to a human fish consumption advisory for mercury by the State of Oregon (Appendix D).

General Concerns. In addition to the general information discussed in Section 2.2.4.2, methylation of mercury is of specific concern within the reservoir environment. Low dissolved oxygen levels and the presence of a substantial amount of organic material near the sediment/water interface can result in higher rates of methylmercury production, as hydrocarbon materials from the organic matter are available to bond with elemental mercury. Methylmercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds as it is much more soluble in water and therefore much more mobile within both the physical reservoir system and the metabolic systems of living organisms living in or utilizing the water.

Water Quality Targets. See Section 2.2.4.2 and Table 2.2.2.

Common Sources. See Section 2.2.4.2.

Historical Data. There are no known historical mercury data for the Oxbow segment (RM 285 to 272.5) of the SR-HC TMDL reach available in either an anecdotal or numeric format.

Table 2.3.25 Mercury monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Mercury Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	None	None (see sources for Brownlee and Upstream segments)

Current Data. There are no known current mercury data for this segment, such as those cited for the Upstream Snake River, Brownlee Reservoir, and Downstream Snake River segments of the SR-HC TMDL reach.

Segment Status. Because the only mercury data available that is applicable (albeit indirectly) to the Oxbow Reservoir segment are from studies conducted in upstream and downstream waters, some interpolations of transport have been made. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow (greater than 99%).
- The majority of sediments delivered to Oxbow Reservoir come from the Brownlee Reservoir outflow. However, many of the heavier sediments that enter Brownlee are

contained there and most mercury adsorbed to or contained within these sediments would be retained in Brownlee.

- Due to the depositional nature of Brownlee Reservoir, the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway potential for mercury from Brownlee into Oxbow Reservoir.
- Because there are no other significant inflows to Oxbow Reservoir, the major source of mercury in Oxbow is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, mercury concentrations in Oxbow Reservoir are not expected to exceed those observed in Brownlee Reservoir (RM 335 to 285) or the Upstream Snake River segment (RM 409 to 335). In a conservative assessment, mercury concentrations in Oxbow Reservoir can be assumed to be equal to or less than those observed in Brownlee Reservoir. It then follows that meeting water quality targets for mercury in Brownlee Reservoir would lead to meeting the targets in Oxbow Reservoir as well.

Upstream data show impairment of the designated beneficial use of fishing. Available upstream data and information demonstrate a high level of concern for the wildlife and hunting designated beneficial use due to observed fish tissue methylmercury concentrations. Collection of water column data is required to determine the status of cold water aquatic life, salmonid rearing, resident fish and aquatic life, and domestic water supply designated beneficial uses.

Nutrients.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed as water quality limited due to nuisance algal growth from excessive nutrient loading. This condition is of concern because of the effect excessive algal growth can have on dissolved oxygen and pH.

General Concerns. See Section 2.2.4.3.

Water Quality Targets. See Section 2.2.4.3 and Table 2.2.2.

Common Sources. See Section 2.2.4.3. The majority of nutrient loading to Oxbow Reservoir is from upstream loading and internal processing within Brownlee Reservoir.

Historical Data. While no historic data exist to document early nutrient concentrations in the this segment Snake River, anecdotal information for upstream segments indicates that algal growth may also have occurred at noticeable levels prior to extensive anthropogenic impact to this reach from agricultural practices or urbanization occurred (US EPA, 1974a).

Current Data. As indicated in Section 2.2.4.3, the two major nutrients of concern in algal productivity are phosphorus and nitrogen. In systems dominated by cyanobacteria (blue-green algae), such as the Brownlee Reservoir segment (RM 335 to 285) at some times of the year

(which represents the primary source of inflow to Oxbow reservoir), phosphorus is usually the limiting agent.

Currently available inflow and in-reservoir data for Oxbow Reservoir include aqueous samples from within the reservoir and from the discharge of Brownlee Reservoir upstream (Tables 2.3.26 and 2.3.27). The data represents both grab samples (primarily within a foot of the surface) and some depth-integrated sampling. While some nutrient and chlorophyll *a* data are available from US EPA (US EPA, 1998a), the majority of in-reservoir data has been collected by IPCo.

Table 2.3.26 Nutrient monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Nutrient Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1974 to 1981	IPCo, 2000c US EPA STORET data, 1998a

Table 2.3.27 Chlorophyll *a* monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Algae Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1991 to 1999	IPCo, 2000c

Total Phosphorus. Within Oxbow Reservoir, combined data show that the water quality targets established by the SR-HC TMDL for total phosphorus are not met nearly 100 percent of the time. Data collected during May, June and July show the lowest levels of total phosphorus (0.03 mg/L to 0.05 mg/L). Data collected during March and April show the highest total phosphorus concentrations (0.2 mg/L to 0.3 mg/L). While these data show a substantial decrease over the concentrations observed in the Upstream Snake River segment (RM 409 to 335) and above the thermocline in Brownlee Reservoir, they also indicate that nutrient targets are routinely not being met during the spring months, and are met less than 25 percent of the time during the fall and winter as total phosphorus concentrations of 0.1 mg/L are commonly observed during the months of August through February.

In the case of phosphorus loading, a less than or equal to 0.07 mg/L phosphorus concentration is the target for the SR-HC TMDL. Total phosphorus monitoring data collected from inflows to Oxbow Reservoir (from Brownlee Reservoir) routinely exceed these values. Available data show that the median total phosphorus concentration in-reservoir was above 0.08 mg/L and the highest total phosphorus levels were 0.23 mg/L in March 1995 (IPCo, 2000c).

Ortho-Phosphate. Combined data collected during May, June and July show the lowest levels of ortho-phosphate (0.01 mg/L to 0.03 mg/L). Data collected from August through February show the highest ortho-phosphate concentrations (0.08 mg/L to 0.1 mg/L).

Because of the interaction of nutrients, algae, dissolved oxygen and pH; algal biomass has been monitored through sampling and analysis for chlorophyll *a* and pheophytin (a metabolite of chlorophyll *a*). Data available from both nutrient and algal monitoring has been identified as an important part of the assessment of water quality. Therefore, these data have been included in the monitoring information on algae even though they are not specifically listed as parameters on the 303(d) list.

Chlorophyll a. Combined data collected during the summer, fall and winter months (July through December) show the lowest levels of chlorophyll *a* (0 ug/L to 3 ug/L). Data collected during the spring and early summer months (April, May and June) show the highest chlorophyll *a* concentrations (12 ug/L to 65 ug/L). While these data show a substantial decrease over the concentrations observed in the Upstream Snake River segment (RM 409 to 335) and above the thermocline in Brownlee Reservoir, they also indicate that the threshold value of 15 ug/L chlorophyll *a* is routinely exceeded during these months in the reservoir.

During the critical summer months (June through September) when conditions for algal growth are optimal, concentrations in Oxbow Reservoir at the Brownlee Dam outflow average 0.07 mg/L total phosphorus, 0.04 mg/L ortho-phosphate and 3 ug/L chlorophyll *a* (1995 to 1999).

Segment Status. Nutrient concentrations in Oxbow Reservoir are shown in Figures 2.3.25 and 2.3.26. Recent monitoring shows that within the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach, water quality tends to be fairly static upstream to downstream.

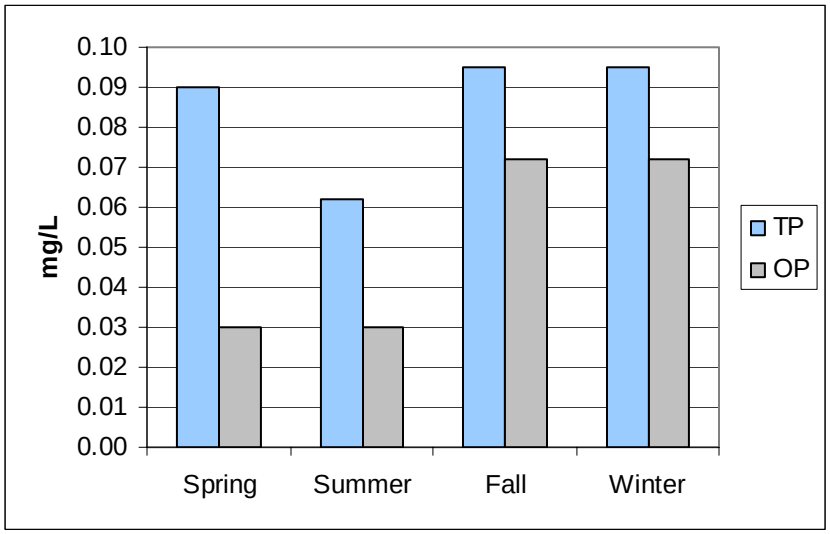

Figure 2.3.25 Mean total phosphorus (TP) and ortho-phosphate (OP) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

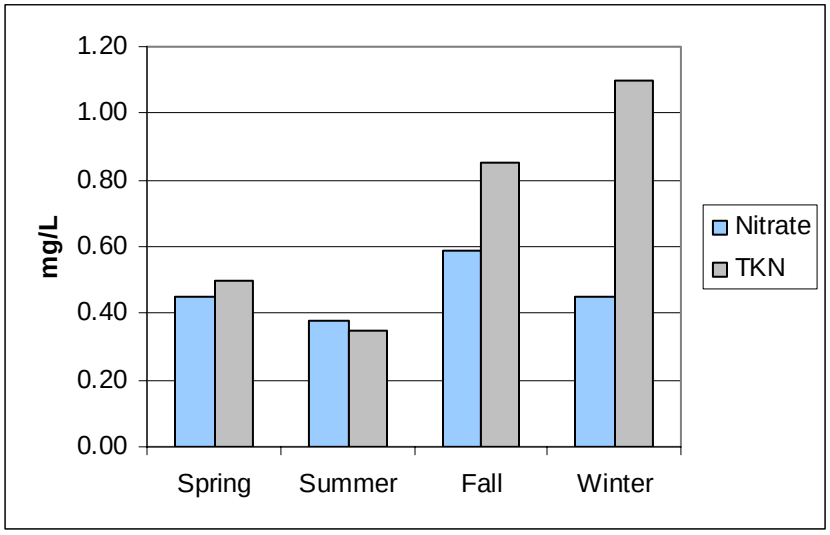

Figure 2.3.26 Mean nitrate and total jeldahl nitrogen (TKN) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Samples for total phosphorus taken at the discharge from Brownlee Dam and at Oxbow Dam on the same days vary by less than 10 percent. For ortho-phosphate, the difference upstream to downstream is 3 percent. Chlorophyll *a* concentrations vary by 35 percent upstream to downstream, exhibiting much less variability than Brownlee Reservoir where concentrations vary by an average of 82 percent upstream to downstream. Oxbow Reservoir is relatively small and fast flowing; therefore water column constituents are fairly well mixed and evenly distributed upstream to downstream. Due to the highly correlated nature of the Oxbow and Brownlee Reservoir systems, water-chemistry and algal loading in the Brownlee Reservoir outflow heavily influences water quality within Oxbow Reservoir. Average ortho-phosphate concentrations in Oxbow Reservoir are observed to be slightly higher than those observed in Brownlee Reservoir during the growing season. Average total phosphorus concentrations in Oxbow Reservoir are somewhat lower, and average chlorophyll *a* concentrations dramatically lower than those seen in Brownlee Reservoir during the growing season.

In addition to the nutrient loads entering the reservoir from upstream, algae can be both grown in place in the reservoir and delivered to this segment from inflowing waters. Growing season reservoir conditions provide adequate light penetration (low turbidity, as sediment loads are primarily deposited in Brownlee Reservoir), and temperatures for algal growth. Although chlorophyll *a* data for the Oxbow Reservoir is limited, algal blooms are observed to occur in the late spring (March and April) and summer months (July and August) (IPCo, 2000c), throughout the relatively short length of the reservoir. Blooms have not been observed to be as excessive as those observed in the upstream portions of Brownlee Reservoir. Decomposition of dead algae leads to the reduction of oxygen in the water column and the conversion of particulate organic phosphorus to highly available, highly mobile, dissolved ortho-phosphate.

Pesticides.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed because of concern over elevated levels for pesticides. Available data (Rinella *et al.*, 1994; Clark and

Maret, 1998) from upstream indicates that the pesticides of concern are legacy pesticides that are no longer licensed for use. These include the chlorinated hydrocarbon insecticide DDT and its breakdown products, and the cyclodiene insecticide dieldrin.

General Concerns. Pesticide residues represent a water quality concern as these substances can be composed of organic chemicals or inorganic elements that are toxic to aquatic life at relatively low concentrations. These substances can kill aquatic life directly or affect the food chain by building up (bioaccumulating and bioconcentrating) to concentrations in lower organisms that can be toxic to the consumers at the upper end of the food chain (including humans).

Water Quality Targets. Pesticide levels of concern for the protection of aquatic life and human health for tissue and water consumption are available through the US EPA toxics rule (used by IDEQ) and ODEQ Table 20, as cited in Table 2.1 of this document. In order to meet the water quality criteria of both states and to support the designated uses of fishing and domestic water supply, the following targets have been established for the SR-HC TMDL reach: 0.024 ng/L water column DDT; 0.83 ng/L water column DDD; 0.59 ng/L water column DDE; and 0.07 ng/L water column dieldrin (Table 2.2.2).

Common Sources. The primary source of these legacy pesticide residues in the SR-HC TMDL reach is upstream historical use of agricultural chemicals for pest control. These compounds have extremely slow degradation rates and therefore are persistent in the environment.

Historical Data. There are no known historical pesticide data available in either an anecdotal or numeric format for this segment.

Current Data. All of the pesticide data available are fish tissue and sediment data in the Upstream Snake River, Brownlee Reservoir, and Downstream Snake River segments of the SR-HC TMDL reach. No pesticide data specific to Oxbow Reservoir are known to exist. There are also no water column pesticide data available except for those collected in the Upstream Snake River segment (RM 409 to 335) (Rinella *et al*., 1994).

Table 2.3.28 Pesticide monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Pesticides Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	None	None (See Clark and Maret, 1998; Rinella *et al.*, 1994 for Brownlee and Upstream segments)

Segment Status. The only pesticide data available that is applicable (albeit indirectly) to the Oxbow reservoir segment (RM 285 to 272.5) are from studies conducted in upstream and downstream waters. These data are primarily from fish and sediment analysis with only a very small data set from the water column.

Many of the same physical and chemical processes that control mercury transport also control pesticide transport. Therefore the same interpolations of transport made for mercury have been applied to the assessment of legacy pesticides. The following facts and assumptions were applied in the interpolation process.

- The outflow from Brownlee Reservoir represents the predominant source of water for Oxbow (greater than 99%).
- The majority of sediments delivered to Oxbow Reservoir come from the Brownlee Reservoir outflow.
- Due to the depositional nature of Brownlee Reservoir, the sediments carried in the outflow are heavily weighted toward smaller, finely divided particles and organic matter.
- These smaller particles and associated organic matter represent a substantial adsorption and transport pathway for the pesticides (observed in Brownlee Reservoir) to move into Oxbow Reservoir.
- Because there are no other significant inflows to Oxbow Reservoir, the major source of pesticides in Oxbow Reservoir is assumed to be Brownlee Reservoir and upstream tributary inflows.

Therefore, pesticide concentrations in Oxbow Reservoir are not expected to exceed those observed in Brownlee or the upstream Snake River segments. In a conservative assessment, pesticide concentrations in Oxbow can be assumed to be less than or equal to those observed in Brownlee. Average pesticide fish tissue levels in Brownlee are: 60 ug/kg DDT; 1600 ug/kg DDD; 216 ug/kg DDE; and 51.5 ug/kg dieldrin (Rinella, *et al.*, 1994; Clark and Maret, 1998). However, the existing data set is very small (18 fish tissue data points, 4 water column data points, 8 sediment data points). Therefore, more data would be very helpful in the determination of impaired, threatened or full support status of these designated beneficial uses.

Sediment.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for sediment. Additional, more detailed information on sediment is included in Section 3.5.

General Concerns. See Section 2.2.4.5.

Water Quality Targets. See Section 2.2.4.5 and Table 2.2.2.

Common Sources. See Section 2.2.4.5. The majority of sediment loading to Oxbow Reservoir is sediment processed through Brownlee Reservoir.

Historical Data. Anecdotal information available indicates that this segment of the SR-HC TMDL reach has historically carried a substantial sediment load particularly during spring runoff. However there is little quantitative data from earlier periods (particularly prior to the construction of the Hells Canyon Complex).

Current Data. Total suspended sediment data has been collected for the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach as shown in Table 2.3.29. While some total suspended sediment data are available from US EPA (US EPA, 1998a), the majority of the

data have been collected by IPCo and are from the Brownlee Dam outflow. These data should be representative of the system as a whole as the Brownlee Dam outflow constitutes over 99 percent of the flow into Oxbow Reservoir.

Data collected show the concentration of total suspended sediment ranges between low values of 2 mg/L to 8 mg/L (early winter months), and high values of 11 mg/L to 26 mg/L (April and May) and 8 mg/L to 215 mg/L (late winter months). While these data show instantaneous values that are in excess of those identified as sediment targets for the SR-HC TMDL, they were not collected in a fashion that would allow determination of duration. However, the maximum concentrations observed during the late winter months are well above the 50 mg/L monthly average sediment target established by the SR-HC TMDL.

Segment Status. The data listed in Table 2.3.29 represent outflow total suspended sediment data from Brownlee Dam and limited data available from habitat assessments of the Wildhorse River inflow. Because over 99 percent of the total inflow to Oxbow Reservoir comes directly from the Brownlee Reservoir outflow, total suspended sediment levels in Oxbow Reservoir are expected to be similar to those observed in the outflow from Brownlee Reservoir. Figure 2.3.27 shows available total suspended sediment concentrations for the Oxbow Reservoir segment (RM 285 to 272.5). The increase in total suspended sediment concentration observed in the winter months is most probably due to the release of water from Brownlee Reservoir for flood control during late winter months. Fine sediments entrained in the release flows from Brownlee Reservoir along with sediments in the tail waters of Oxbow Reservoir disturbed by the incoming water combine to increase total suspended sediment for a brief period of time.

Wildhorse River experiences seasonal and precipitation-driven variability in total suspended sediment concentrations. Higher total suspended sediment concentrations occur with snowmelt and precipitation events that result in increased flow volume and velocity. These inputs contribute a relatively small amount of sediment to the reservoir and are not projected to represent a substantial source of the overall sediment load to the reservoir.

Table 2.3.29 Total suspended solids monitoring for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Sediment Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1974 to 1981	IPCo, 2000c US EPA STORET data, 1998a

Using the Brownlee Reservoir outflow as the primary source of flow to the reservoir, total suspended sediment concentrations in Oxbow Reservoir would be expected to average less than or equal to 5.4 mg/L near the inflow. Sediment constituents are expected to be weighted toward finely divided particles, (most probably silt and clay) due to the settling effect observed in Brownlee Reservoir. Due to the relatively short length of the Oxbow Reservoir (12 miles), and the relatively short retention time (1.4 days), a substantial portion of the suspended particles would be expected to pass through to the downstream segments of the SR-HC TMDL reach.

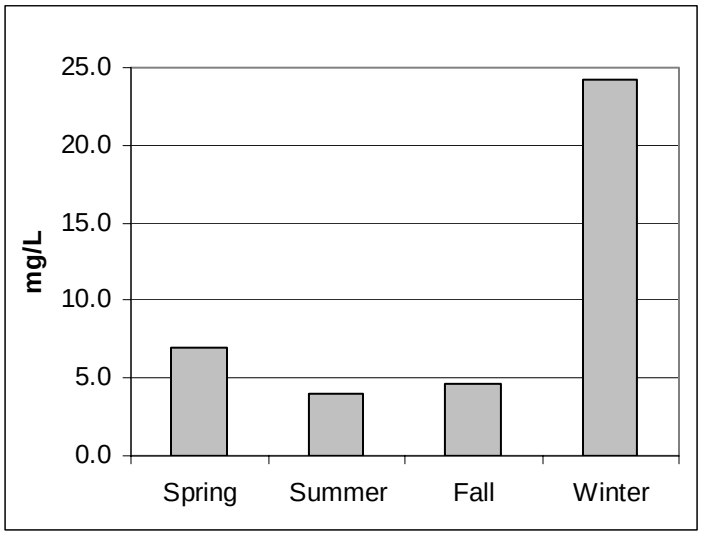

Figure 2.3.27 Mean total suspended solids (TSS) concentrations for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Sediment transport, and the transport and delivery of sediment-bound pollutants are directly associated with increased flow volumes and high velocities. Sedimentation process within Oxbow Reservoir (and Hells Canyon Reservoir downstream to an even greater degree) is reduced due to the depositional processes that occur in Brownlee Reservoir. (For more detail see the discussion of sedimentation in Brownlee Reservoir in Section 2.3.2.) Larger size particles (sands and gravels) and the associated sediment-bound pollutants are not often transported to Oxbow Reservoir, as they tend to accumulate in the upper portion of Brownlee Reservoir. Sediment in Oxbow Reservoir is expected to consist predominantly of smaller silt and clay particles and some heavier colloidal matter. As Oxbow Reservoir is not operated for flood control, it is not expected that this sediment is often re-entrained into the water column by processes other than significant increases in flow due to flood control releases from Brownlee Reservoir and exceptional runoff events such as the 1997 flooding.

Available data do not contain duration information and therefore are not sufficient to determine if cold water aquatic life, salmonid rearing, or residential fish and aquatic life designated beneficial uses are impaired due to direct sediment effects. However, measured concentrations do not indicate that sediment caused impairment is occurring for cold water aquatic life or salmonid rearing designated beneficial uses. Sediment targets are set to be protective of these uses. Additionally, due to the fact that sediment acts as a primary transport mechanism for adsorbed pollutants, sediment targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

Temperature.

The Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach is listed for temperature due to violations of Oregon water quality standards, including numeric and narrative criteria for salmonid rearing/cold water aquatic life, and resident fish and aquatic life.

General Concerns. See Section 2.2.4.6.

Water Quality Targets. See Section 2.2.4.6 and Table 2.2.2.

Common Sources. See Section 2.2.4.6.

Historical Data. Available historical temperature data from 1954 through 1957 at the Oxbow Reservoir Dam site (USFWS, 1957 and 1958) show daily maximum and average temperature measurements that exceed the temperature targets for the SR-HC TMDL (see Table 2.3.30). The sampling location of the 1950s data is given only as the Oxbow Dam site so it is assumed to be the same as the current dam site, RM 272.5. These data, when combined with information on historical water management occurring upstream of RM 272.5 and available air temperature data, indicate that waters in this segment probably experienced warming due to both anthropogenic and non-anthropogenic sources prior to dam construction.

Table 2.3.30 Temperature measurements from Oxbow Reservoir Dam site from 1954 to 1957 (USFWS 1957, 1958).

	Temperature (^{o}C)							
Month	**1954**		**1955**		**1956**		**1957**	
	Mean Ave.	Mean Max.	Mean Ave.	Mean Max.	Mean Ave.	Mean Max.	Mean Aver.	Mean Max.
January	n.a.	n.a	0.9	1.1	2.9	3.2	1.1	1.3
February	5.8	6.2	1.7	1.9	1.8	2.1	2.9	3.0
March	6.9	7.5	5.0	5.4	6.3	6.6	7.1	7.2
April	11.6	12.2	9.5	9.9	10.7	11.0	10.7	11.1
May	15.7	16.3	14.2	14.7	14.8	15.3	15.0	15.5
June	17.7	18.4	19.2	19.8	17.8	18.4	19.0	19.5
July	23.9	24.6	22.2	22.8	24.6	25.1	22.4	22.7
August	20.9	21.4	23.0	23.5	22.3	22.8	21.7	22.0
September	17.7	18.1	18.9	19.2	19.2	19.6	18.1	18.5
October	11.6	12.9	13.0	13.3	n.a.	n.a.	12.7	13.0
November	7.9	8.1	5.1	6.2	n.a.	n.a.	6.9	7.1
December	2.3	2.6	3.4	3.6	n.a.	n.a.	4.2	4.4

Current Data. Current temperature data available for the Oxbow Reservoir segment (RM 285 to 272.5) include monitoring of both tributary and mainstem values. Water temperature data for some areas of the drainage extend back to the early 1960's, and represent a variety of high and low annual precipitation levels. Daily maximum, mean and minimum water temperatures are recorded at the inflow to Oxbow Reservoir but collection frequency and period of record for the other areas of the reservoir varies considerably. Table 2.3.31 contains data sources for water temperatures observed in Oxbow Reservoir.

Table 2.3.31 Temperature monitoring information for the Oxbow Reservoir segment (RM 285 to 272.5) of the Snake River - Hells Canyon TMDL reach.

Segment	Temperature Monitoring Dates	Source
Oxbow Reservoir (RM 285 to 272.5)	1992 to 1999 1965 to 1980	IPCo, 2000c US EPA STORET data, 1998a

Photo 2.3.4. The mainstem Snake River near the Oxbow Dam site (RM 272.5), circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

Segment Status. A plot of historic vs. current temperature in the Oxbow Reservoir segment (RM 285 to 272.5) is shown in Figure 2.3.28. The plotted data show that pre- and post-impoundment temperature values are relatively similar over all.

The primary source of water inflowing to Oxbow Reservoir is Brownlee Reservoir, immediately upstream (greater then 99% of the total inflow). Water released from the deep penstocks of Brownlee Dam maintains a fairly stable temperature. The average summer temperature of inflowing water is 18 ^{o}C (64.4 ^{o}F). The average winter season temperature of inflowing water is approximately 5 ^{o}C (41 ^{o}F). Due to the short residence time, the temperature of water moving downstream through Oxbow Reservoir increases only minimally (less than 3 ^{o}C (5.4 ^{o}F) over the length of the reservoir). As there are relatively few anthropogenic influences on temperature in the Oxbow Reservoir area outside of the hydropower facilities themselves, temperature increases within the surface layers of the reservoir are most likely due to solar radiation and high summer air temperatures. Daily maximum and minimum water temperatures show a wider overall range

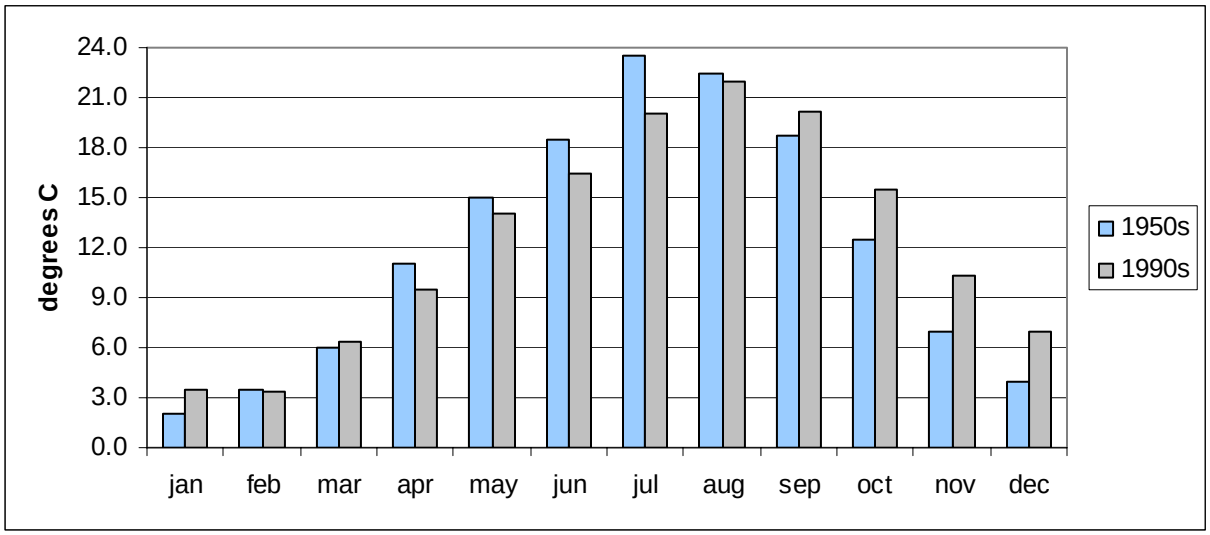

Figure 2.3.28. Pre-impoundment (1950s) vs. post-impoundment (1990s) water temperatures at Oxbow Dam (RM 272.5) in the Snake River - Hells Canyon TMDL reach.

and greater total variance as distance from Brownlee Dam increases. The data presented in Figure 2.3.28 show cooler maximum water temperatures (approximately 3.5 ^{o}C) in the summer months post-impoundment as compared to pre-impoundment water temperatures. The plotted data also show a temporal shift in maximum temperatures similar to that observed in the outflow from Brownlee Dam (Figure 2.3.23). The timing of temperature maxima post-impoundment is shifted slightly later in the year as compared to pre-impoundment maxima. The magnitude of the shift is comparable to that observed in the outflow from Brownlee Dam, approximately one month (~30 days).

Wildhorse Creek flows into Oxbow Reservoir immediately below Brownlee Dam. Water temperatures in Wildhorse Creek exhibit more seasonal variability than the penstock releases from Brownlee Dam, with annual maximum temperatures reaching 20 ^{o}C (68 ^{o}F), usually in July or August; and annual minimum temperatures dropping to less than 4 ^{o}C (39 ^{o}F) in the winter months of December or January. As the relative flow contribution of Wildhorse Creek is so small (less than 1% of the total inflow), changes in temperature within Oxbow Reservoir due to Wildhorse inflows are assumed to be minimal.

Available data show exceedences of temperature criteria throughout the surface waters of the SR-HC TMDL reach during the months of June, July, August and September. Cold water aquatic life and salmonid rearing designated uses are supported in the Oxbow Reservoir segment (RM 285 to 272.5) due to the presence of cold water refugia.

Total Dissolved Gas.

General Concerns. See Section 2.2.4.7.

Water Quality Targets. See Section 2.2.4.7 and Table 2.2.2.

Common Sources. See Section 2.2.4.7.

Historical Data. There are no historical total dissolved gas data available.

Current Data.. The current data on total dissolved gas have been collected by IPCo. Spill tests were conducted at Brownlee Dam on June 4, 1998 at a spill level of 39,000 cfs. The total dissolved gas levels observed from spilling through the upper gates averaged 114 percent of saturation while spill through the lower gates averaged 127.7 percent of saturation. Spill from Brownlee Dam was identified as the largest influence on total dissolved gas concentrations within Oxbow and Hells Canyon Reservoirs (IPCo, 1999b, 1999f). However, while elevated total dissolved gas concentrations from spill at Brownlee Dam have been observed to have an effect on the total dissolved gas in Oxbow and Hells Canyon reservoirs, the effect is not observed to extend to the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach.

Segment Status. Exceedences of the total dissolved gas target of less than 110 percent occur in both Oxbow and Hells Canyon reservoirs (as related to spill from Brownlee Dam in excess of 2,000 to 3,000 cfs).

Elevated total dissolved gas levels from spills through the Hells Canyon Complex reservoirs may be a significant factor in resident and anadromous fish survival both in the reservoirs and downstream in the Snake River. A study by IPCo determined that in general, spills in excess of 2,000 to 3,000 cfs result in total dissolved gas levels that exceed the state standard of less than 110 percent of saturation both within the reservoirs and downstream in the Snake River (IPCo, 1998c, 1999b, 1999f).

During the period of no spill, the state standard of less than 110 percent of saturation total dissolved gas within the Snake River below Hells Canyon Dam was always met (IPCo, 1999b).

2.3.3.3 DATA GAPS

See Section 2.4

2.3.3.4 POLLUTANT SOURCES

See Section 2.5

Point Sources

There are no known permitted point sources that discharge directly to Oxbow Reservoir outside of the permit for discharge from Brownlee Dam. This permit applies to miscellaneous discharge water only, not water released directly through the dam.

Nonpoint Sources

Nonpoint sources discharging to the mainstem Snake River in the SR-HC TMDL reach include agricultural, recreational, urban/suburban, and forestry land use, as well as ground water and natural and background loading.

Agricultural.

A very limited amount of cropping occurs within the Oxbow Reservoir drainage. No known agricultural return flows have been identified within the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. Grazing occurs to a limited extent in some areas within this segment but animal densities are minimal.

Recreational.

Due to its proximity to populated urban areas and the excellent recreational opportunities available, Oxbow Reservoir is a major destination site year-round. Water-based recreational activities peak in the summer season with heavy use observed between Memorial Day weekend and Labor Day weekend, when the reservoir is used by many boaters, swimmers, campers and anglers. The average use of the reservoir (May 1997 through October 1998) is estimated at 721,124 visitor hours annually. Peak use during a week has been estimated at 48,436 visitor hours (July 4th), and monthly peak use levels estimated at 145,310 visitor hours (July). Camping and bank-fishing use is also substantial in this segment (IPCo, 2000b; HCNRA, 1998a and 1998b, 1999a and 1999b).

Urban/Suburban.

A minor amount of the urban/suburban land within the SR-HC TMDL reach is located in the drainage area of the Oxbow Reservoir segment (RM 285 to 272.5). Rural residential housing supported by septic systems is present within this segment but densities are minimal.

Ground Water.

Many natural springs and ground-water inflows have been observed in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. These inflows occur in the tributary drainages and the reservoir system, entering both above and below the water level in many locations. Subsurface recharge from irrigation water use is estimated to be minimal in the Oxbow Reservoir segment due to low irrigation water usage in this area. Natural ground-water inputs are estimated to dominate over subsurface recharge in most areas of this segment.

Background and Natural Contributions.

The natural sources of pollutants discussed in Section 2.5 are known to be present to some degree in the Oxbow Reservoir segment (RM 285 to 272.5) of the SR-HC TMDL reach. However, the occurrence of natural sources of mercury is more prevalent in tributaries to the Upstream Snake River segment (RM 409 to 335) and the Brownlee Reservoir segment (RM 335 to 285) than in the Oxbow Reservoir segment (RM 285 to 272.5).

2.3.3.5 POLLUTION CONTROL EFFORTS

See Section 2.6.

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